TECHNICAL MEMORANDUM CH2MHILL

Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

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This Technical Memorandum (TM) presents groundwater supply alternatives for three cities in the Lower Colorado Regional Water Planning Group (Region K) whose projected use will exceed their available supply through the year 2050. Following is a summary of the groundwater supply alternatives developed for Blanco, Goldthwaite, and Llano and information on the methods and assumptions used in this evaluation.

A summary comparison of these groundwater supply options is presented in Table 1 on the following page. In each of the groundwater options described, it is assumed that existing Rights of Way (ROWs), specifically roadway ROWs, can be followed for the majority of the pipelines needed. Also, the impacts to the streams and rivers in and around the areas of interest will see minimal impacts from these well fields. Routing power to the well field sites in order to drill the wells is assumed to be a minimal problem as well; each of the areas involved have existing well fields and this implies that power is available.

TABLE 1
Summary Comparison of the Groundwater Supply Options for all three cities.
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

	Blanco – Option 1	Blanco – Option 2	Goldthwaite	Llano
County	Blanco	Blanco	Mills	Llano
Average Supply (ac-ft/yr)	52	52	117	660
Water Management Strategy	8 wells in the Hensell/Cow Creek; 1.5 mi. west of Blanco	2 wells in the Ellenburger Group; 11 mi. north of Blanco	3 wells in the Trinity Group; 1 mi. southwest of Goldthwaite	7 wells in the Ellenburger Group; 7 mi. southeast of Llano

TABLE 1
Summary Comparison of the Groundwater Supply Options for all three cities.
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

	Blanco – Option 1	Blanco – Option 2	Goldthwaite	Llano
Capital / Project Costs	$1,875,000	$2,790,000	$1,060,000	$3,540,000
Debt Service	$135,000	$200,000	$75,000	$260,000
O&M Cost	$8,500	$30,000	$11,000	$15,000
Total Annual Cost	$143,500	$230,000	$86,000	$275,000
Cost $/1000 gal.	$8.47	$2.35	$2.26	$1.28
Cost $/ac-ft	$2,760	$767	$735	$416

Groundwater Options

Blanco

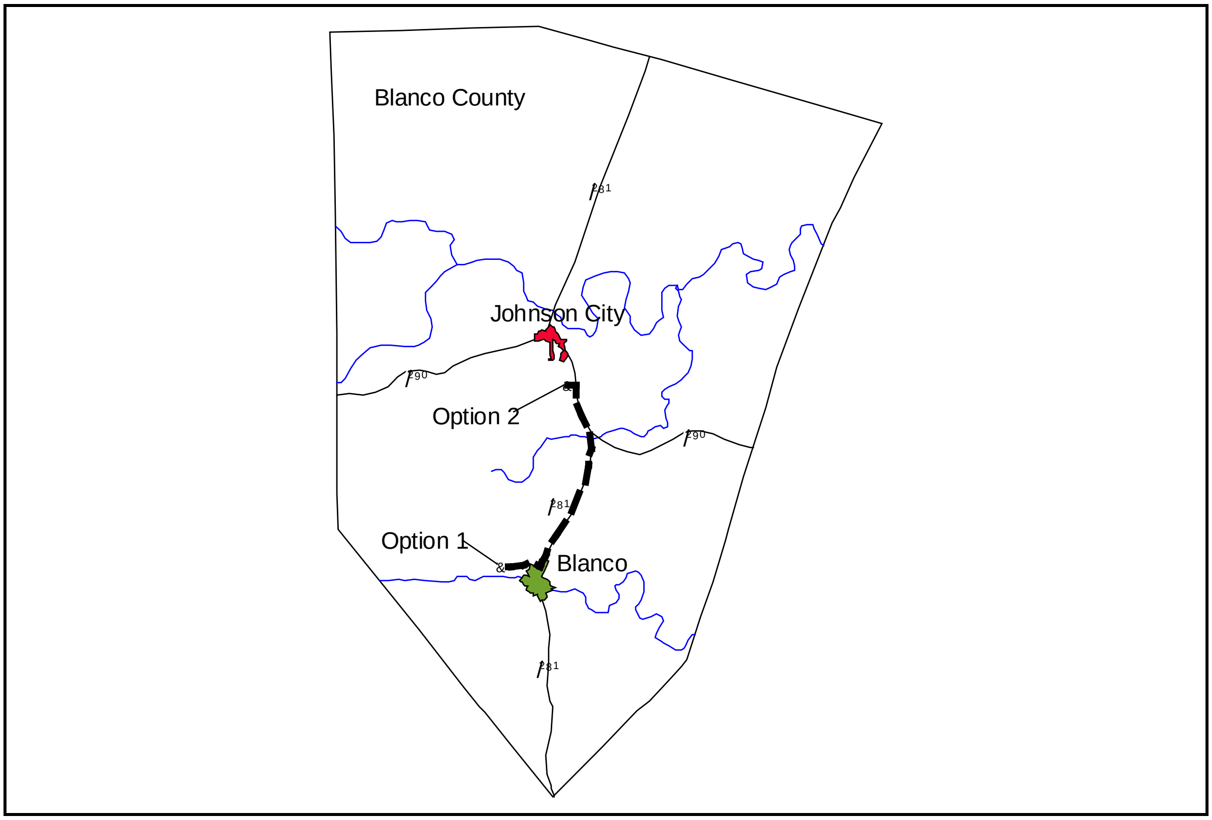
According to the demand projections and water availability analysis, the City of Blanco will have a maximum water shortage of 52 acre-feet per year this year. To determine groundwater options available for this area, the following resources were consulted: Texas Water Development Board (TWDB) Report 346 - The Paleozoic and Related Aquifers of Central Texas (March 1996), TWDB Report 339 - Evaluation of the Ground-Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas (August 1992), and TWDB well information posted in ASCII format on: ftp://rio.twdb.state.tx.us/gwdata/Database%20in%20ASCII/. A general knowledge of the groundwater resources for the area and conversations with a staff member of the TWDB, the manager of the Hill Country Underground Water Conservation District (HCUWCD), and a local drilling contractor were also applied to develop potential groundwater supply option. Two options, as shown in Figure 1, will be discussed here, one in which a new well field will be located approximately 1.5 miles northwest of the water treatment plant and one in which a new well field will be located approximately 11 miles north of Blanco (just south of Johnson City).

Option 1 – Well Field in the Blanco Area

In discussions with the TWDB, it was learned that they had recently drilled two wells in the Blanco area. These wells are 400-500 feet deep and are pulling water from the Cow Creek and Hensell members of the Travis Peak Formation in the middle Trinity Group. These wells are approximately 1.5 miles outside the city limits and yield water at roughly 5 gallons per minute (gpm). The well information obtained from the TWDB ftp site confirmed this data.

Using this information, it was assumed that additional wells drilled in the Blanco area would draw from the Cow Creek and Hensell members as well. Table 2 gives more information about these hydrologic units.

FIGURE 1 BLANCO GROUNDWATER SUPPLY OPTIONS



The location suggested for these new wells is approximately 1.5 miles northwest of the City's water treatment plant. This direction was chosen so that pipelines would not need to cross the Blanco River. The production capacity of each well was assumed to be 5 gpm at a well depth of 500 feet. Comparing topographic maps of the area with the water level maps given in the literature resulted in a depth to water of 60 feet. The area's transmissivity was also taken from the literature. This was assumed to be 1,000 gallons per day per foot (gpd / ft). Existing wells drilled in the area also have 10-inch diameter screens in the lower 100 feet. These dimensions were applied to the proposed wells. Well efficiency was assumed to be 80 percent.

TABLE 2
Blanco Area Geological and Hydrological Units and Their Water-Bearing Properties*
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

Geological Units		
Era	Mesozoic	
System	Cretaceous	
Group	Trinity Group	
Formation	Travis Peak Formation	
Member or Unit	Cow Creek Member	Hensell Member
Hydrological Units	Middle Trinity Aquifer	
Approximate Range in Thickness (feet)	0-100 (pinches-out northward and northwestward)	10-±300 (thins eastward)
Character of Rocks	Massive, locally crossbedded, highly fossiliferous, white to gray, sandy, argillaceous to dolomitic limestone with local thin layers of sand, shale, lignite, gypsum and anhydrite.	Red to gray clay, silt, sand, sandstone, conglomerate and thin limestone beds. Thickest sand and sandstone predominate around Llano uplift. Limestone underlain by sandstone predominates in areas farther away from Llano uplift.
Water-Bearing Properties	Yields small to very large quantities of fresh to moderately saline water to wells. With proper well construction and proper acidizing, well yields may be increased two-fold. With proper acidizing, well yields have been reported to have increased from 325 gallons per minute to 700 gallons per minute. Yields very small to small quantities of fresh water to numerous small springs.	
*Information taken from the Texas Water Development Board's Report 339: Evaluation of the Ground-Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill County of Central Texas (August 1992).		

Well Cost

This information was then used to obtain a cost for a system of 8 wells producing the desired 52 acre-feet per year. Well costs were estimated at $18.00 per inch of diameter-foot of well depth. This may seem high but is due to the rocky nature of the area. The complete wellhead, including an electric motor and pump, was estimated at $8,000 per inch of diameter or $64,000. The cost associated with electric power was $0.06 per kilowatt-hour. Other operations and maintenance (O&M) costs were assumed to be 1 percent of the wellfield capital cost, and the contingency added for engineering and other services was 35 percent. Table 3 provides a summary of the costs presented here. Note that these calculations do not include the collection/transmission piping nor any expenses associated with obtaining the land or water rights needed for the well field.

Collection/Transmission Piping Cost

Only 1” and 2” piping is needed to move the water from the wells to the Blanco Water Treatment Plant. The cost used for estimating piping installations was $11.25 per linear foot of 1” piping installed and $12.50 per linear foot of 2” piping installed. It was assumed that PVC piping would be used and that the O&M cost for it would be about 1 percent of the pipeline capital cost. With the well field approximately 1.5 miles from the water treatment plant, wells spaced approximately 0.25 miles away from each other, and the design flows mentioned earlier, 1.25 miles of 1” piping and 2.0 miles of 2” piping are required. Please note that these lengths are station-to-station lengths and do not account for topographic effects of the area. A 30 percent contingency is used in the piping estimate to account for this factor.

The total unit costs for this groundwater supply option are $2,055 per acre-foot or $6.31 per thousand gallons.

TABLE 3
Well Costs Obtained for the Blanco Area
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

	Cost Per Well	Cost for Well System	Cost for Pipeline	Entire System
Wells/Piping	$90,000	$720,000	$206,250	-
Site Piping, Sitework, and Pump	$8,000	$64,000	-	-
Contingency	$34,300	$274,400	$61,875	-
Wellfield/Pipeline Total	$132,300	$1,058,400	$268,125	$1,326,525
Annual O&M Total	$1,074	$8,447	$2,062.50	$10,510
Annual Capital Cost	$9,611	$76,892	$19,479	$96,371
Total Annual	$10,686	$85,339	$21,541	$106,880
Unit Cost per acre-foot	$1,325	$1,641	$414	$2,055
Unit Cost per 1,000 gallons	$4.07	$5.04	$1.27	$6.31

Notes:
The unit cost for the well system is higher than the cost per well because this cost includes all wells, some of which may not be operating at all times.
The Site Piping, Sitework, and Pump cost category was calculated using the pipe size obtained and rounding that number up to the nearest available pipe size.
The Annual Capital Cost was calculated by annualizing the Wellfield Total, using an interest rate of 6 percent and an expected life of 30 years.

Option 2 – Well Field in the Johnson City Area

In discussions with the HCUWCD and a local drilling contractor, it was learned that the City of Johnson City had wells that were drawing from the Ellenburger Group. These wells are also fairly shallow at 200-300 feet deep and yield water in excess of 200 gpm. The Ellenburger Group extends just south of Johnson City, and this was investigated as a viable location for a well field to be used by the City of Blanco.

Using this information, it was assumed that additional wells drilled in the Johnson City area would draw from the Ellenburger Group as well. Table 4 gives more information on this hydrologic unit.

The location suggested for these new wells is approximately 11 miles north of Blanco. The production capacity of each well was assumed to be 200 gpm at a depth of 260 feet and a diameter of 6 inches; two wells were assumed for maintenance purposes. Comparing topographic maps of the area with the water level maps given in the literature resulted in a depth to water of 179 feet. The area's transmissivity was also taken from the literature. This was assumed to be 20,000 gallons per day per foot (gpd/ft). Existing wells drilled in the area also have the lower reaches of the well open (no screens), so additional wells were assumed to have the lower 70 feet open. Well efficiency was assumed to be 95 percent.

Well Cost

To accurately compare the cost of this option with the cost of the water supply available from Canyon Lake in the south, the above information was then used to obtain a cost for a system of 2 wells producing 300 acre-feet per year. Well costs were estimated at $12.00 per inch of diameter-foot of well depth. This number is lower than the previous option due to the shallowness of the wells. The complete wellhead, including an electric motor and pump, was estimated at $8,000 per inch of diameter. The cost associated with electric power was $0.06 per kilowatt-hour. Other operations and maintenance (O&M) costs were assumed to be 1 percent of the wellfield capital cost and the contingency added for engineering and other services was 35 percent. Table 5 provides a summary of the costs presented here. Note that these calculations do not include the collection/transmission piping nor any expenses associated with obtaining the land or water rights needed for the well field.

Collection/Transmission Piping Cost

Only 4" piping is needed to move the water from the wells to the Blanco Water Treatment Plant, assuming that only one well will be used the majority of the time. The cost used for estimating piping installations was $15.00 per linear foot of 4" piping installed. It was assumed that PVC piping would be used and that the O&M cost for it would be about 1 percent of the pipeline capital cost. With the well field approximately 11 miles from the water treatment plant, wells spaced approximately 0.25 miles away from each other, and the design flows mentioned earlier, 11.25 miles of 4" piping are required. Please note that this length is a station-to-station length and does not account for topographic effects of the area. A 30 percent contingency is used in the piping estimate to account for this factor.

The total unit costs for this groundwater supply option are $375 per acre-foot or $1.15 per thousand gallons.

TABLE 4
Blanco Area Geological and Hydrological Units and Their Water-Bearing Properties*
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

Geological Units				
Era	Paleozoic			
System	Ordovician			
Group	Ellenburger Group			
Formation	Honeycut Formation	Gorman Formation	Tanyard Formation	
Member or Unit	Not Differentiated	Not Differentiated	Staendebach Member	Threadgill Member
Hydrological Units	Ellenburger-San Saba Aquifer			
Approximate Range in Thickness (feet)	0-850 (truncated by erosion northwestward)	280-500 (partially truncated by erosion northwestward)	475-730 (thins westward)	
Character of Rocks	Thinly to thickly bedded, light-gray, aphanitic limestone and thinly to thickly bedded, fine-grained to microgranular, gray dolomite. Both limestone and dolomite have fossiliferous chert.	Predominantly aphanitic light gray limestone in upper part and predominantly micro-granular to fine-grained, pink, gray and yellowish-gray dolomite in lower part. Has prominent bed containing fossiliferous chert nodules near middle of formation.	Thickly to thinly bedded, aphanitic, very light gray, cherty limestone and thickly to thinly bedded, fine to medium grained, gray to brownish gray, cherty dolomite. Chert is fossiliferous.	Predominantly medium to coarse grained, light gray dolomite which may locally and laterally grade to massive, light gray limestone. Lower part may be Cambrian in age.
Water-Bearing Properties	Yields very small to very large quantities of fresh to slightly saline water to wells in the Pedernales River Valley in Gillespie and Blanco Counties. Yield of a well is very dependent on the amount and size of fracture openings and cavities encountered by the well bore. Where such openings are encountered, wells may be capable of yielding over 1,000 gallons per minute. Where such openings are not encountered, wells may yield less than 5 gallons per minute. Where limestone (calcium carbonate) is encountered, well yields may be significantly increased by acidizing. Yields small to very large quantities of fresh water to springs in northwestern Gillespie County and northern Blanco County.			

*Information taken from the Texas Water Development Board’s Report 339: Evaluation of the Ground-Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill County of Central Texas (August 1992).

TABLE 5
Well Costs Obtained for Blanco in the Johnson City Area
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

	Cost Per Well	Cost for Well System	Cost for Pipeline	Entire System
Wells/Piping	$18,720	$37,440	$891,000	-
Site Piping, Sitework, and Pump	$48,000	$96,000	-	-
Contingency	$23,352	$46,704	$267,300	-
Wellfield/Pipeline Total	$90,072	$180,144	$1,158,300	$1,338,444
Annual O&M Total	$6,142	$6,426	$8,910	$15,336
Annual Capital Cost	$6,544	$13,087	$84,149	$97,236
Total Annual	$12,686	$19,513	$93,059	$112,573
Unit Cost per acre-foot	$39	$65	$310	$375
Unit Cost per 1,000 gallons	$0.12	$0.20	$0.95	$1.15

Notes:
The unit cost for the well system is higher than the cost per well because this cost includes all wells, some of which may not be operating at all times.
The Site Piping, Sitework, and Pump cost category was calculated using the pipe size obtained and rounding that number up to the nearest available pipe size.
The Annual Capital Cost was calculated by annualizing the Wellfield Total, using an interest rate of 6 percent and an expected life of 30 years.

Goldthwaite

According to the demand projections and water availability analysis, the City of Goldthwaite will have a maximum water shortage of 117 acre-feet per year this year. To determine groundwater options available for this area, the following resources were consulted: TWDB Report 319 – Evaluation of Water Resources in Part of Central Texas (January 1990), a general knowledge of the groundwater resources for the area, and TWDB well information posted in ASCII on ftp://rio.twdb.state.tx.us/gwdata/Database%20in%20ASCII/.

The TWDB well information available for Mills County gave information on four of the City of Goldthwaite's wells, and this information was used in evaluating the available options. These wells are around 500 feet deep and are pulling water from the Travis Peak Formation in the Trinity Group. These wells are approximately 1 mile outside the city limits and yield water at roughly 30 gallons per minute (gpm).

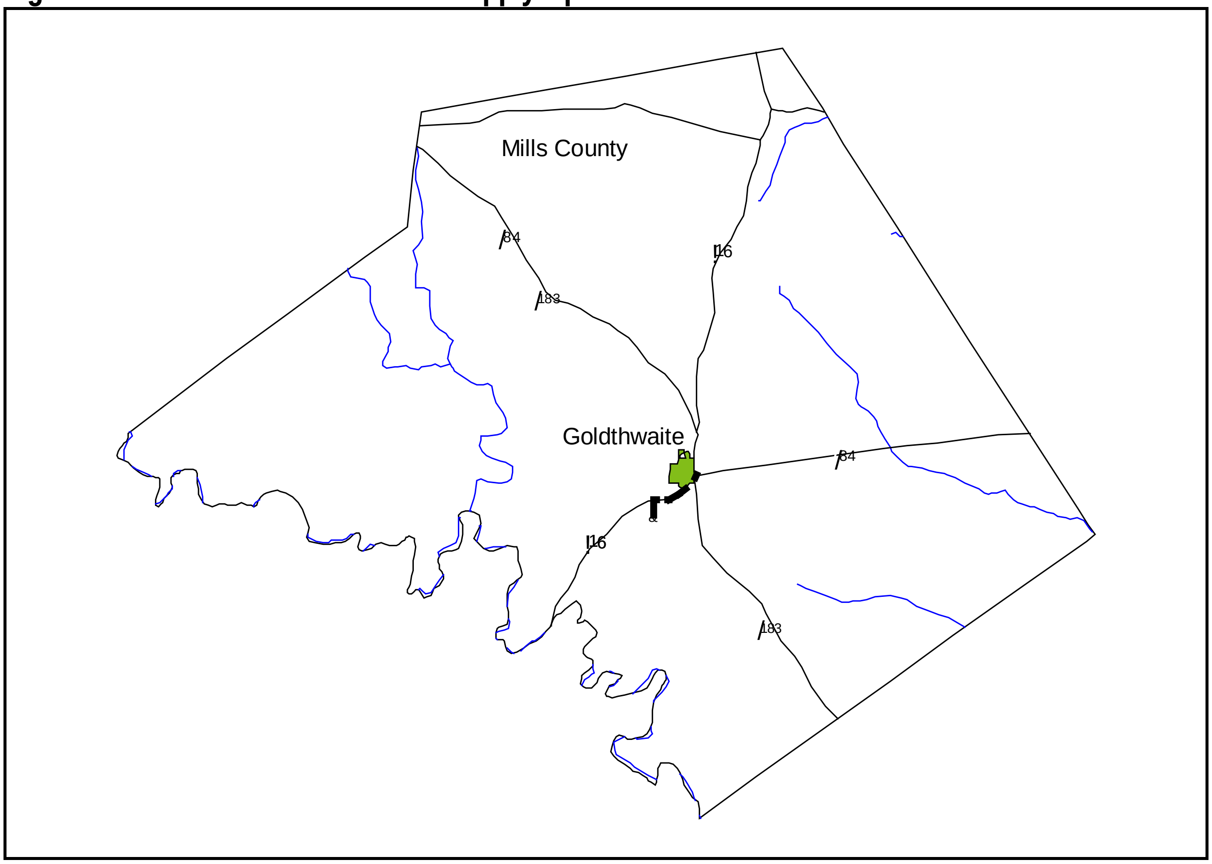
Using this information, it was assumed that additional wells drilled in the Goldthwaite area would draw from the Travis Peak Formation as well. Table 6 gives more information on this hydrologic unit.

TABLE 6
Goldthwaite Area Geological and Hydrological Units and Their Water-Bearing Properties*
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

Geological Units						
Era	Mesozoic					
System	Cretaceous					
Group	Trinity					
Formation	Antlers Formation					
	Travis Peak Formation					
Member or Unit	Hensell Sand Member	Pearsall Member	Cow Creek Limestone Member	Hammett Shale Member	Sligo Member	Hosston Member
Hydrological Units	Middle Trinity				Lower Trinity	
Approximate Range in thickness (feet)	175	85	130	140	130	1,550
Character of Rocks	Sand, gravel, conglomerate, sandstone, siltstone, & shale. Grades into sandy limestone and dolomite.	Predominately shale interbedded with sand; however, in the calcareous facies, the unit is composed almost entirely of calcareous sediments.	Massive, often sandy, dolomitic limestone, frequently forming cliffs and waterfalls. Contains gypsum & anhydrite beds.	Shale & clay with some sand, dolomitic limestone & conglomerate.	Limestone, dolomite, occasionally sandy, & shale. Thins to the west.	Basal conglomerate grading upward into a mixture of sand, siltstone, & shale, with some limestone beds.
Water-Bearing Properties	Yields small to large quantities of fresh to slightly saline water.	Not known to yield water in the study area.			Yields moderate to large quantities of fresh to moderately saline water.	
*Information taken from the Texas Water Development Board's Report 319: Evaluation of Water Resources in Part of Central Texas (January 1990).						

The location suggested for these new wells is approximately 1 mile southwest of the city limits, as shown in Figure 2. The production capacity of each well was assumed to be 30 gpm at a well depth of 550 feet. Comparing topographic maps of the area with the water level maps given in the literature resulted in a depth to water of 400 feet. The area's transmissivity was also taken from the literature. This was assumed to be 2,000 gpd/ft. Existing wells drilled in the area also have 8-inch diameter screens in the lower 70 feet. Well efficiency was assumed to be 80 percent.

Figure 2 Goldthwaite Groundwater Supply Option



Well Cost

This information was then used to obtain a cost for a system of 3 wells producing the desired 117 acre-feet per year. Well costs were estimated at $18.00 per inch of diameter-foot of well depth. This may seem high but is due to the rocky nature of the area. The complete wellhead, including an electric motor and pump, was estimated at $8,000 per inch of diameter, or $48,000. The cost associated with electric power was $0.06 per kilowatt-hour. Other operations and maintenance (O&M) costs were assumed to be 1 percent of the wellfield capital cost, and the contingency for engineering and other services used was 35 percent. Table 7 provides a summary of the costs presented here. Note that these calculations do not include the collection/transmission piping nor any expenses associated with obtaining the land or water rights needed for the well field.

Collection/Transmission Piping Cost

Only 2” and 4” piping is needed to move the water from the wells to the Goldthwaite Water Treatment Plant. The cost used for estimating piping installations was $12.50 per linear foot of 2” piping installed and $15.00 per linear foot of 4” piping installed. It was assumed that PVC piping would be used and that the O&M cost for it would be about 1 percent of the pipeline capital cost. With the well field approximately 1 mile from the water treatment plant, wells spaced approximately 0.25 miles away from each other, and the design flows mentioned earlier, 0.5 miles of 2” piping and 1 mile of 4” piping are required. Please note that these lengths are station-to-station lengths and do not account for topographic effects of the area into. A 30 percent contingency is used in the piping estimate to account for this.

The total unit costs for this groundwater supply option are $432 per acre-foot or $1.32 per thousand gallons.

TABLE 7
Well Costs Obtained for the Goldthwaite Area
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

	Cost Per Well	Cost for Well System	Cost for Pipeline	Entire System
Wells/Piping	$79,200	$237,600	$135,960	-
Site Piping, Sitework, and Pump	$16,000	$48,000	-	-
Contingency	$33,320	$99,960	$40,788	-
Wellfield/Pipeline Total	$128,520	$385,560	$176,748	$562,308
Annual O&M Total	$3,204	$8,301	$1,359.60	$9,660
Annual Capital Cost	$9,337	$28,011	$12,841	$40,851
Total Annual	$12,541	$36,311	$14,200	$50,511
Unit Cost per acre-foot	$259	$310	$121	$432
Unit Cost per 1,000 gallons	$0.80	$0.95	$0.37	$1.32

Notes:
The unit cost for the well system is higher than the cost per well because this cost includes all wells, some of which may not be operating at all times.
The Site Piping, Sitework, and Pump cost category was calculated using the pipe size obtained and rounding that number up to the nearest available pipe size.
The Annual Capital Cost was calculated by annualizing the Wellfield Total, using an interest rate of 6 percent and an expected life of 30 years.

Llano

According to the demand projections and water availability analysis, the City of Llano will have a maximum water shortage of 660 acre-feet per year this year. To determine groundwater options available for this area, the following resources were consulted: TWDB Report 346 – The Paleozoic and Related Aquifers of Central Texas (March 1996), a general knowledge of the groundwater resources for the area, and conversations with a drilling contractor familiar with the area of interest.

In discussions with the local drilling contractor, it was learned that wells had recently been drilled in the Riley Mountain area. The area is rather rocky, but the wells yield water at 70-100 gpm. These wells are about 600 feet deep, 6 inches in diameter, and pulling water from the Ellenberger-San Saba aquifer.

Using this information, it was assumed that additional wells drilled in the Llano area would draw from the Ellenberger-San Saba aquifer as well. Table 8 gives more information on this hydrologic unit.

TABLE 8
Llano Area Geological and Hydrological Units and Their Water-Bearing Properties*
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

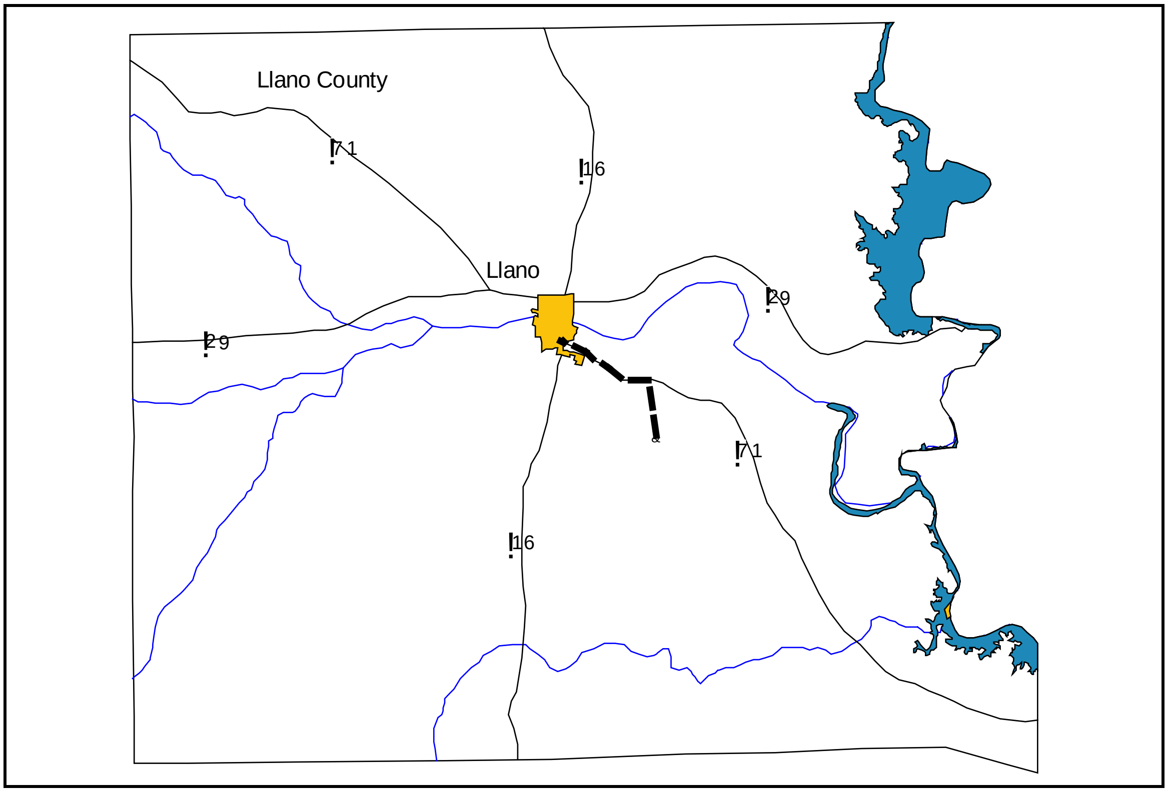
Geologic Units					
Era	Paleozoic				
System	Ordovician				Cambrian
Group	Ellenburger Group				Moore Hollow Group
Formation	Honeycut Formation	Gorman Formation	Tanyard Formation		Wilberns Formation
Member or Unit	Not Differentiated	Not Differentiated	Staendebach Member	Threadgill Member	San Saba Aquifer
Hydrological Unit	Ellenburger-San Saba Aquifer				

TABLE 8
Llano Area Geological and Hydrological Units and Their Water-Bearing Properties*
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

Geologic Units					
Character of Rocks	Thinly to thickly bedded, light-gray, aphanitic limestone and thinly to thickly bedded, fine-grained to microgranular, gray dolomite. Both limestone and dolomite have fossiliferous chert.	Predominantly aphanitic light gray limestone in upper part and predominantly micro-granular to fine-grained, pink, gray and yellowish-gray dolomite in lower part. Has prominent bed containing fossiliferous chert nodules near middle of formation.	Thickly to thinly bedded, aphanitic, very light gray, cherty limestone and thickly to thinly bedded, fine to medium grained, gray to brownish gray, cherty dolomite. Chert is fossiliferous.	Predominantly medium to coarse grained, light gray dolomite which may locally and laterally grade to massive, light gray limestone. Lower part may be Cambrian in age.	Fine to very fine grained, yellowish to brownish to medium gray, thickly to thinly bedded, slightly cherty dolomite. Upper part may be Ordovician in age.
Water-Bearing Properties	Yields very small to very large quantities of fresh to slightly saline water to wells in the Pedernales River Valley in Gillespie and Blanco Counties. Yield of a well is very dependent on the amount and size of fracture openings and cavities encountered by the well bore. Where such openings are encountered, wells may be capable of yielding over 1,000 gallons per minute. Where such openings are not encountered wells may yield less than 5 gallons per minute. Where limestone (calcium carbonate) is encountered well yields may be significantly increased by acidizing. Yields small to very large quantities of fresh water to springs in northwestern Gillespie County and northern Blanco County.				
*Information taken from the Texas Water Development Board’s Report 346: The Paleozoic and Related Aquifers of Central Texas (March 1996).					

The location suggested for these new wells is approximately 7 miles southeast of the city limits (in the Riley Mountain range), as shown in Figure 3. The production capacity of each well was assumed to be 70 gpm at a well depth of 600 feet. Comparing topographic maps of the area with the water level maps given in the literature resulted in a depth to water of 100 feet. The area’s transmissivity was also taken from the literature. This was assumed to be 50,000 gpd/ft. Six-inch diameter screens in the lower 300 feet were assumed. Well efficiency was assumed to be 80 percent.

Figure 3 Llano Groundwater Supply Option



Well Cost
This information was then used to obtain a cost for a well system of 7 wells producing the desired 660 acre-feet per year. Well costs were estimated at $18.00 per inch of diameter-feet of well depth. This may seem high but is due the rocky nature of the area. The complete wellhead, including an electric motor and pump, was estimated at $8,000 per inch of diameter, or $224,000. The cost associated with electric power was $0.06 per kilowatt-hour. Other operations and maintenance (O&M) costs were assumed to be 1 percent of the wellfield capital cost and the contingency for engineering and other services used was 35 percent. Table 9 provides a summary of the costs presented here. Note that these calculations do not include the collection / transmission piping nor any expenses associated with obtaining the land or water rights needed for the well field.

Collection/Transmission Piping Cost
Only 4”, 6” and 8” piping is needed to move the water from the wells to the Llano Water Treatment Plant. The cost used for estimating piping installations was $15.00 per linear foot of 4” piping installed, $17.50 per linear foot of 6” piping installed, and $20.00 per linear foot of 8” piping installed. It was assumed that PVC piping would be used and that the O&M cost for it would be about 1 percent of the pipeline capital cost. With the well field approximately 7 miles from the water treatment plant, wells spaced approximately 0.25 miles away from each other,

and the design flows mentioned earlier, 1 mile of 4" piping, 0.5 mile of 6" piping, and 7 miles of 8" piping are required. Please note that these lengths are station-to-station lengths and do not account for topographic effects of the area. A 30 percent contingency is used for the piping estimate to account for this factor.

The total unit costs for this groundwater supply option are $262 per acre-foot or $0.81 per thousand gallons.

TABLE 9
Well Costs Obtained for the Llano Area
Groundwater Supply Alternatives for the Cities of Blanco, Goldthwaite, and Llano

	Cost Per Well	Cost for Well System	Cost for Pipeline	Entire System
Wells/Piping	$64,800	$453,600	$864,600	-
Site Piping, Sitework, and Pump	$32,000	$224,000	-	-
Contingency	$33,880	$237,160	$259,380	-
Wellfield/Pipeline Total	$130,680	$914,760	$1,123,980	$2,038,740
Annual O&M Total	$2,628	$16,477	$8,646	$25,123
Annual Capital Cost	$9,494	$66,456	$81,656	$148,112
Total Annual	$12,121	$82,933	$90,302	$173,235
Unit Cost per acre-foot	$107	$126	$137	$262
Unit Cost per 1,000 gallons	$0.33	$0.39	$0.42	$0.81

Notes:
The unit cost for the well system is higher than the cost per well because this cost includes all wells, some of which may not be operating at all times.
The Site Piping, Sitework, and Pump cost category was calculated using the pipe size obtained and rounding that number up to the nearest available pipe size.
The Annual Capital Cost was calculated by annualizing the Wellfield Total, using an interest rate of 6 percent and an expected life of 30 years.

References

1. Baker, Bernard, et al. "Evaluation of Water Resources in Part of Central Texas." Texas Water Development Board Report 319. January 1990. Texas Water Development Board: Austin, Texas.

2. Bluntzer, Robert L. "Evaluation of the Ground-Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas." Texas Water Development Board Report 339. August 1992. Texas Water Development Board: Austin, Texas.

3. CH2M HILL. "Preliminary Investigation and Feasibility Analysis: Step 1 Report." April 1998.

4. Preston, Richard D., et al. "The Paliozoic and Related Aquifers of Central Texas." Texas Water Development Board Report 346. March 1996. Texas Water Development Board: Austin, Texas.